Mechanical Power Engineering Department
Faculty of Engineering
Tanta University

2015/2016

FLUID MECHANICS (A)

Dr/Hagar Alm ElDin

Lecturer Mechanical power Engineering



Information

PLACE :

Lectures Hall 11

TIME :

12:45 – ∞ **Saturday**

Office Hours :

11:00 –2:00
Monday &Tuesday

and
by appointment

COURSE OUTLINE

Introduction and basic concepts	[1 LECTURE]
Fluid Properties	[3 LECTURES]
Fluid Statics	[3 LECTURES]
Fluid kinematics	[3 LECTURES]
Conservation of Energy	[3 LECTURES]

TEXT BOOK :

Course notes will be available

OTHER USEFUL BOOKS :

A. Fluid_Mechanics Frank White 5th Ed
B. Viscous Fluid Flow, F.M.White, McGraw Hill
C. Fluid Mechanics - Fox - 6th
D. Fundamental Mechanics of Fluids, I.G.Curie, McGraw HiLL

Grading criteria (Power):

HOMEWORK & PROJECTS	30/150
MIDTERM EXAMS	30/150
(Multiplied wit attendance factor)	
FINAL EXAM	90/150

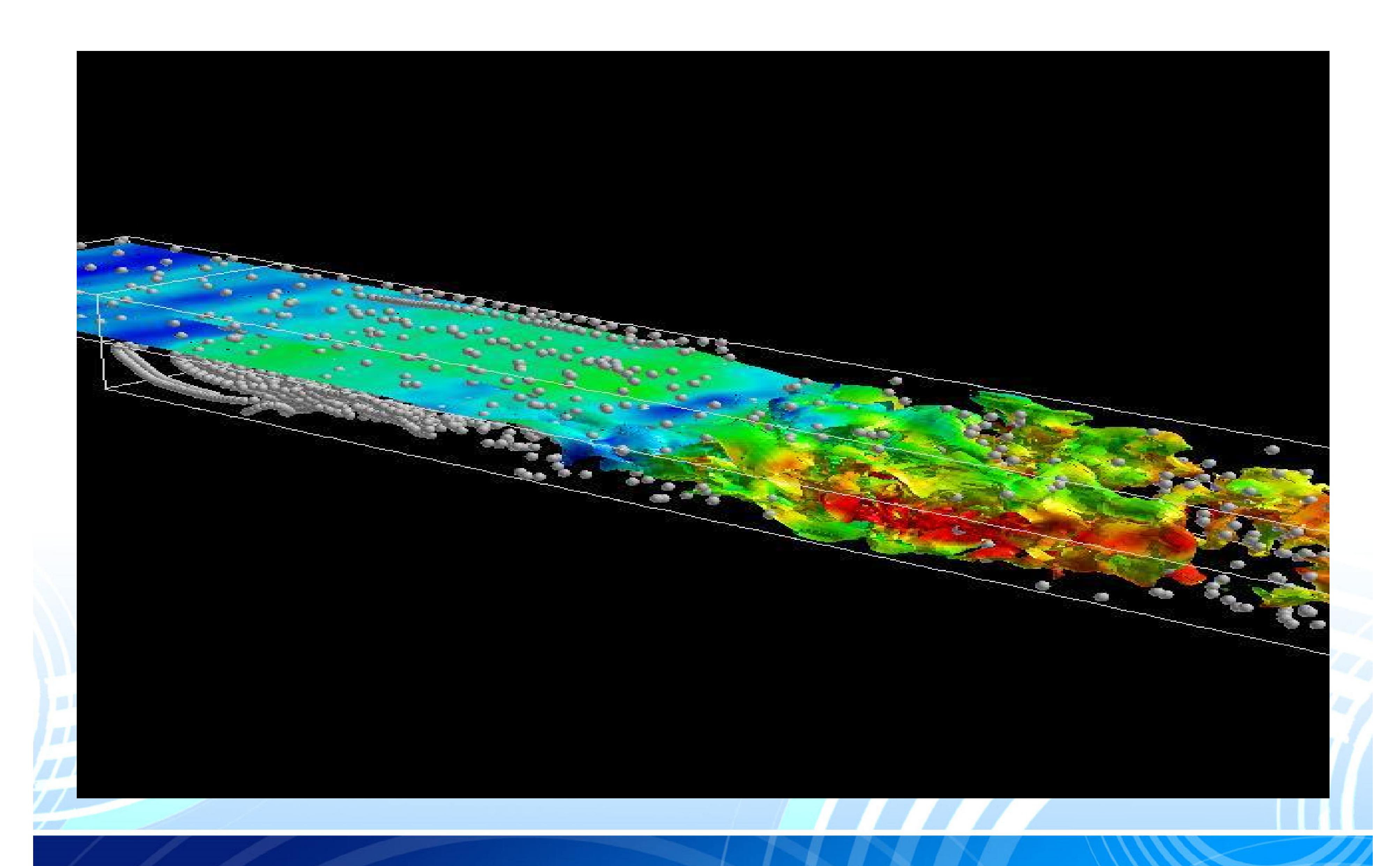
Grading criteria(Production) :

HOMEWORK & PROJECTS	25/125
MIDTERM EXAMS	25/125
(Multiplied wit h attendance factor)	
FINAL EXAM	75/125

Requirements for Course:

- Attend at least 10 Lectures.
- Written Lecture notes by students.
- Solved Problems sheets by students.
- Reports and case studies upon request.







KEEP
CALM
AND
LEARN FLUID
MECHANICS

Introduction

Introduction

- **Mechanics** is the oldest physical science that deals with both stationary and moving bodies under the influence of forces.
- The branch of mechanics that deals with bodies at rest is called **statics,** while the branch that deals with bodies in motion is called **dynamics.** The subcategory **fluid mechanics** is defined as the science that deals with the behavior of fluids at rest (*fluid statics*) or in motion (*fluid dynamics*), and the interaction of fluids with solids or other fluids at the boundaries. Fluid mechanics is also referred to as **fluid dynamics** by considering fluids at rest as a special case of motion with zero velocity (Fig. 1–1).



FIGURE 1–1 Fluid mechanics deals with liquids and gases in motion or at rest. © *Vol. 16/Photo Disc.*



Fluid Mechanics Overview

Fluid Mechanics

- Fluid
  - Gas
    - Air, He, Ar, N_2, etc.
  - Liquids
    - Water, Oils, Alcohols, etc.
  - Properties: Compressibility, Density, Viscosity, Vapor Pressure, Surface Tension
- Mechanics
  - Statics: $\sum F_i = 0$
    - Stability, Pressure, Buoyancy
  - Dynamics: $\sum F_i > 0$, Flows
    - Laminar/Turbulent, Viscous/Inviscid, Steady/Unsteady, Compressible/Incompressible

Chapter 1: Introduction

Chapter 2: Fluid Statics

Fluid Dynamics: Rest of Course

Introduction

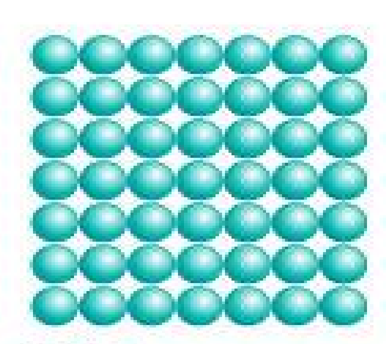
Fluid mechanics itself is also divided into several categories. The study of

- **Hydrodynamics:** the motion of fluids that are practically incompressible (such as liquids, especially water, and gases at low speeds) is usually referred to as.
- A subcategory of hydrodynamics is **hydraulics,** which deals with liquid flows in pipes and open channels.
- **Gas dynamics** deals with the flow of fluids that undergo significant density changes, such as the flow of gases through nozzles at high speeds.
- **Aerodynamics** deals with the flow of gases (especially air) over bodies such as aircraft, rockets, and automobiles at high or low speeds.
- Some other specialized categories such as **meteorology, oceanography,** and **hydrology** deal with naturally occurring flows.

States of Matter

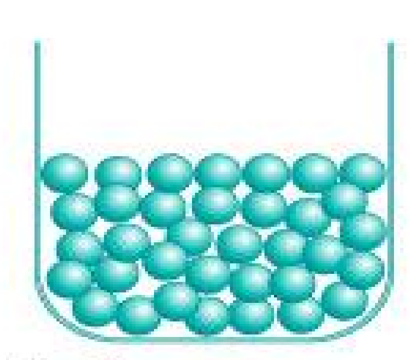
Physical states

increasing energy



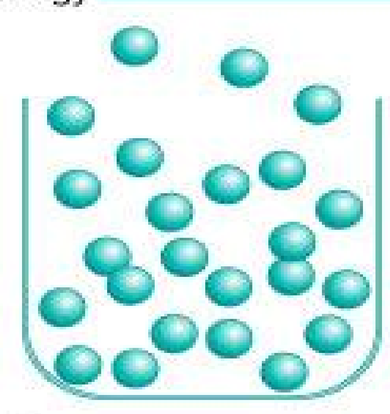
Solid

The molecules that make up a solid are arranged in regular, repeating patterns. They are held firmly in place but can vibrate within a limited area.



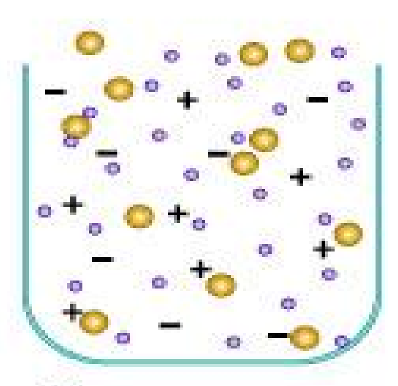
Liquid

The molecules that make up a liquid flow easily around one another. They are kept from flying apart by attractive forces between them. Liquids assume the shape of their containers.



Gas

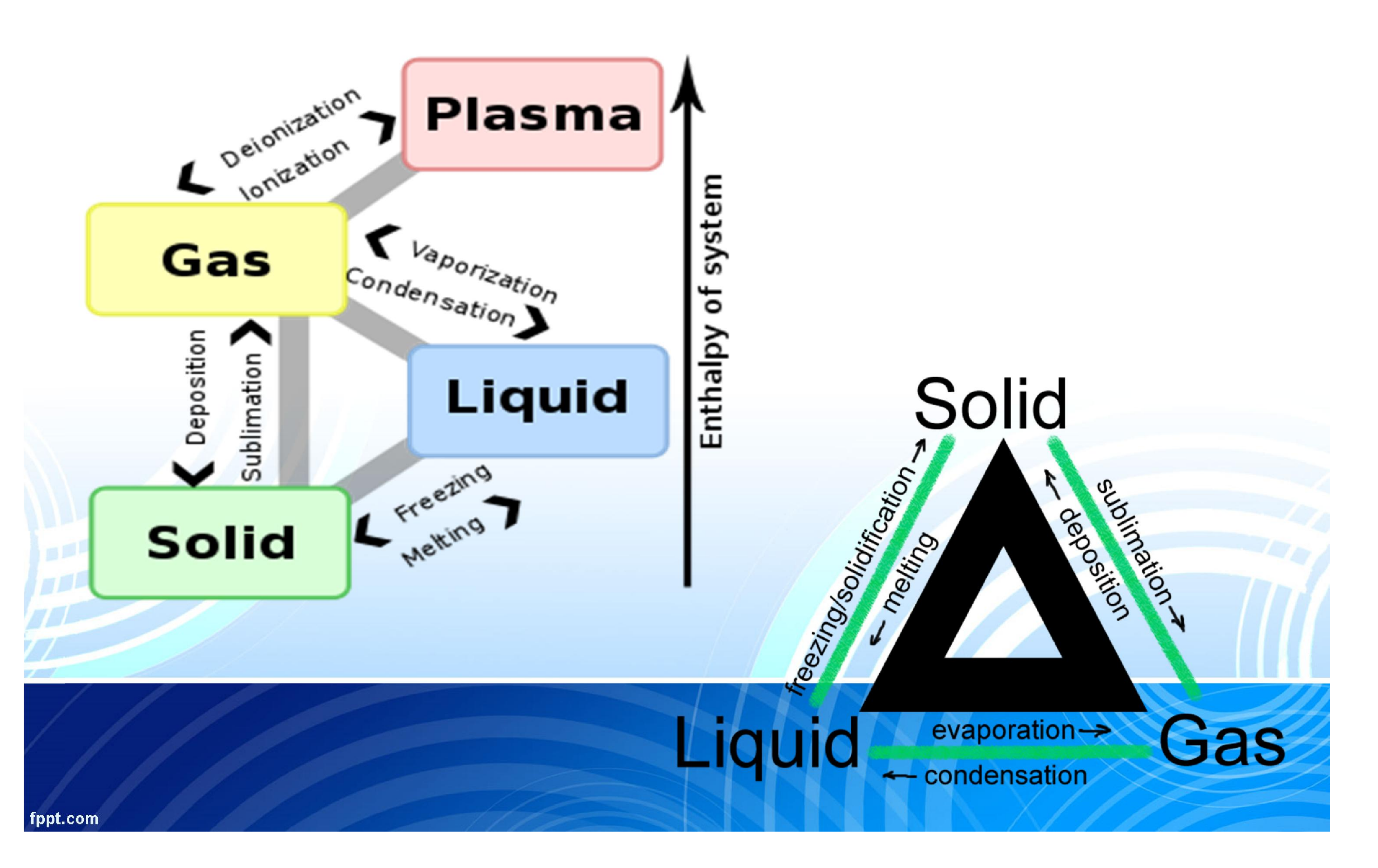
The molecules that make up a gas fly in all directions at great speeds. They are so far apart that the attractive forces between them are insignificant.



Plasma

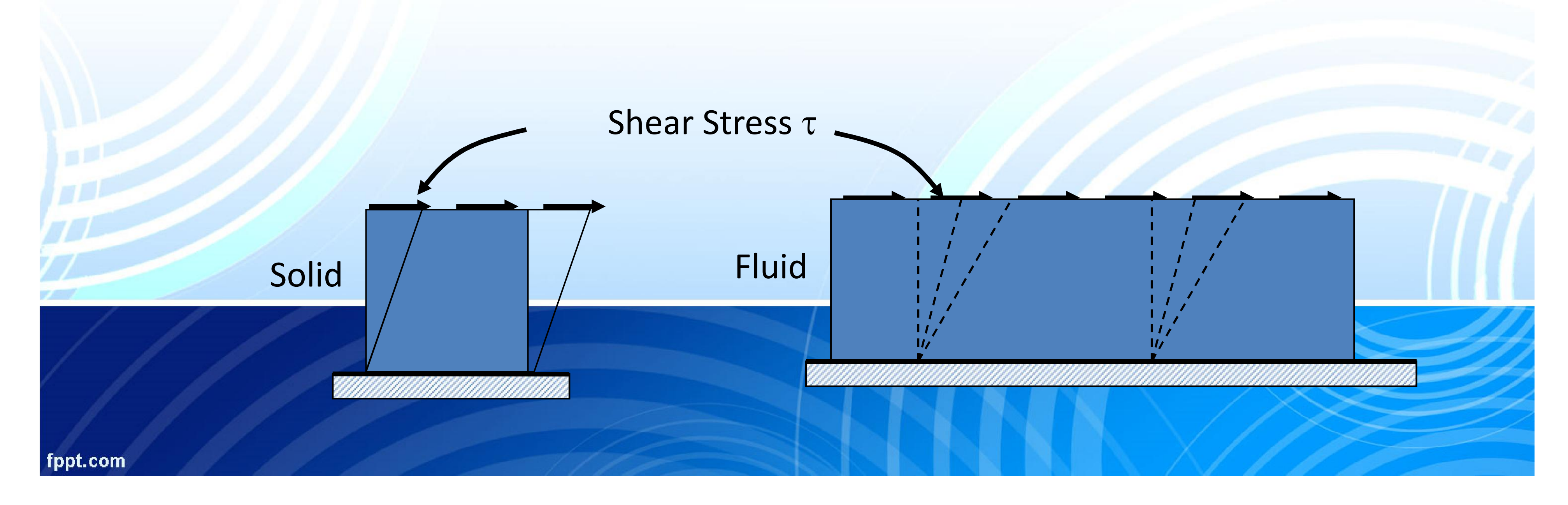
At the very high temperatures of stars, atoms lose their electrons. The mixture of electrons and nuclei that results is the plasma state of matter.

States of Matter



States of Matter

- Fluids (gasses and liquids) and solids
- What's the difference?
  - Fluid particles are free to move among themselves and give way (flow) under the slightest tangential (shear) force



What is a fluid?

- A substance in the liquid or gas phase is referred to as a **fluid.**
- Distinction between a solid and a fluid is made on the basis of the **substance's ability to resist an applied shear (or tangential) stress that tends to change its shape.**
- A solid can resist an applied shear stress by deforming, whereas a fluid deforms continuously under the influence of shear stress, no matter how small.
- In solids **stress is proportional to *strain***, but in fluids stress is proportional to *strain rate*. When a constant shear force is applied, a solid eventually stops deforming, at some fixed strain angle, whereas a fluid never stops deforming and approaches a certain rate of strain.

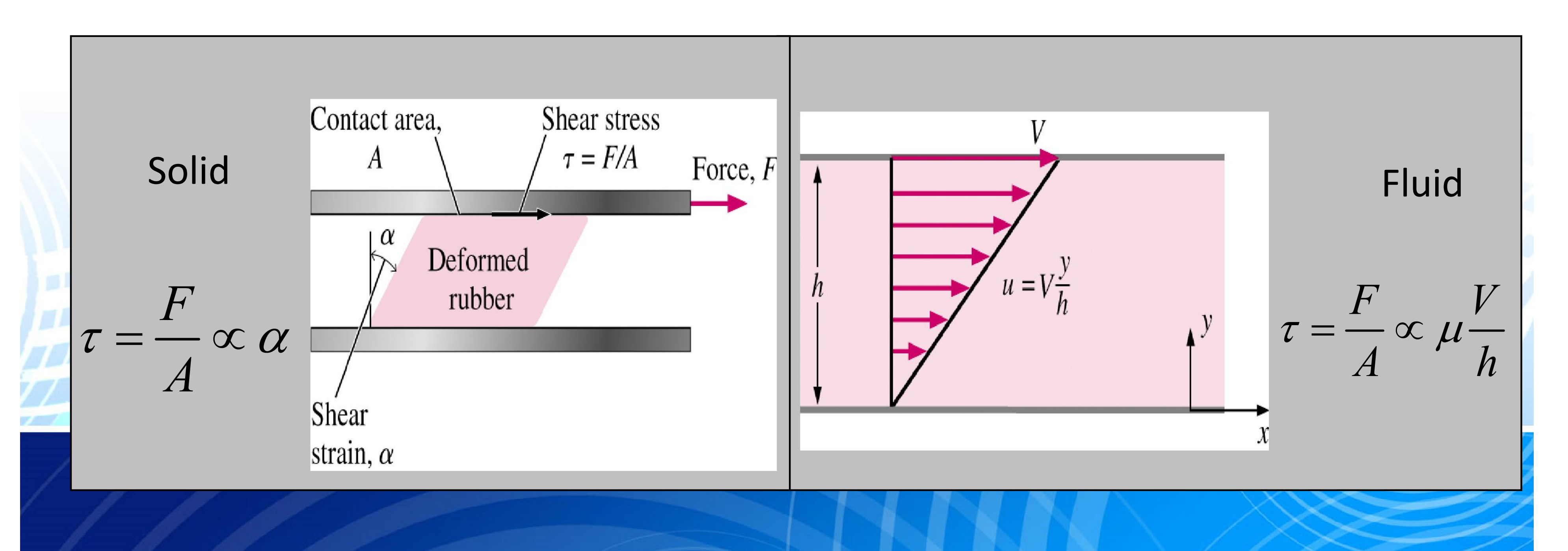
Fluid Vs Solid

- For a solid **the strain is a function of the applied stress (providing that the elastic limit has not been** reached). For a fluid**, the rate of strain is proportional to the applied stress.**

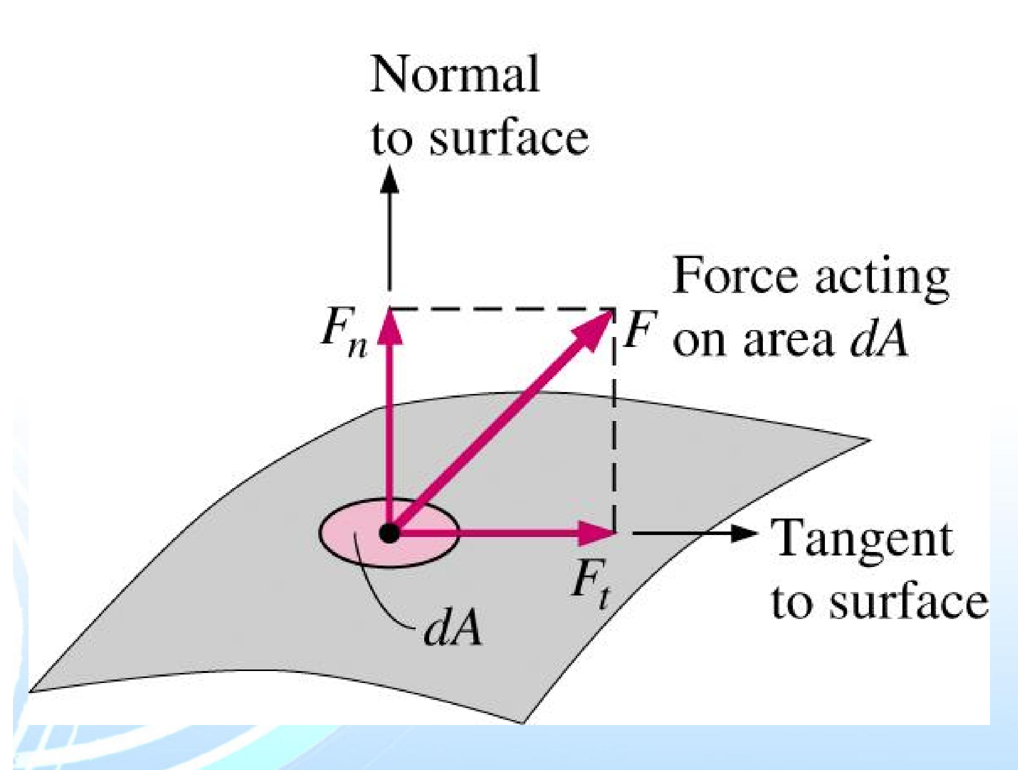
- The strain in a solid **is independent of the time over which the force is applied and (if the elastic limit** is not reached) the deformation disappears when the force is removed. A fluid **continues to flow for as** long as the force is applied and will not recover its original form when the force is removed.

What is a fluid?

- Distinction between solid and fluid?
  - Solid: can resist an applied shear by deforming. Stress is proportional to strain
  - Fluid: deforms continuously under applied shear. Stress is proportional to strain rate

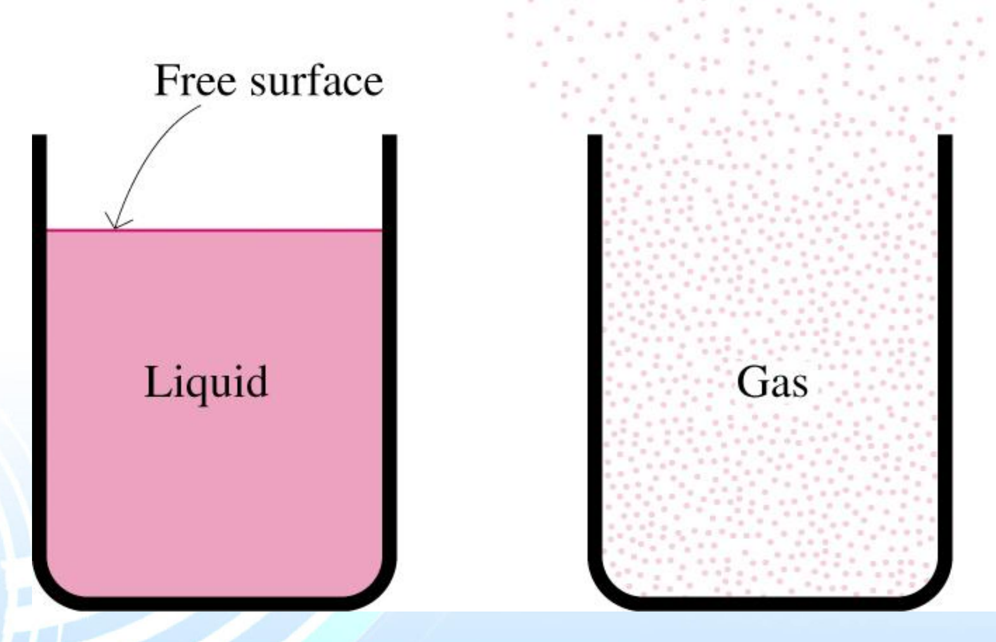


What is a fluid?



- Stress is defined as the force per unit area.
- Normal component: normal stress
  - In a fluid at rest, the normal stress is called **pressure**
- Tangential component: shear stress

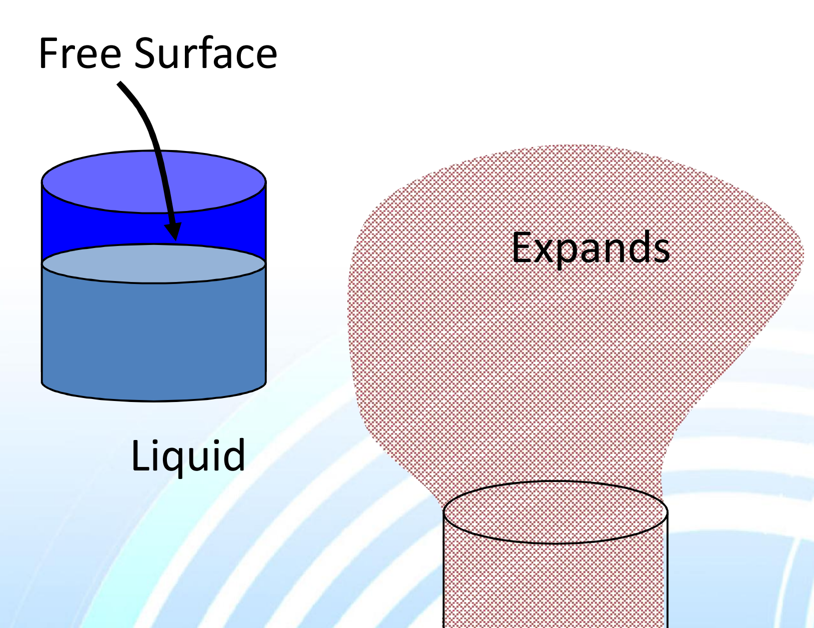
What is a fluid?



- A liquid takes the shape of the container it is in and forms a free surface in the presence of gravity
- A gas expands until it encounters the walls of the container and fills the entire available space. Gases cannot form a free surface
- Gas and vapor are often used as synonymous words

Classes of Fluids

- Liquids and gasses – What's the difference?
  - **Liquids:** Close packed, strong cohesive forces, retains volume, has free surface
  - **Gasses:** Widely spaced, weak cohesive forces, free to expand



Common Fluids

- Liquids:
  - water, oil, mercury, gasoline, alcohol
- Gasses:
  - air, helium, hydrogen, steam
- Borderline:
  - jelly, asphalt, lead, toothpaste, paint, pitch

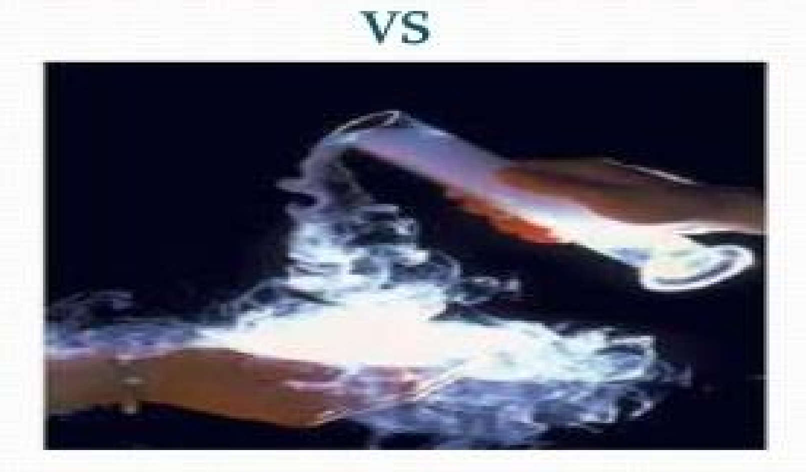
Gas Vs. Vapor

Difference between gas and vapor

Gas	Vapor
A gas refers to a substance that has a single defined thermodynamic state at room temperature .	A Vapor refers to a substance that is a mixture of two phases at room temperature, namely gaseous and liquid phase.
At the temperature of interest, gases do not condense.	at the temperature of interest, vapors can be in equilibrium with their liquid state



VS



Is there a difference between a gas and a vapor?

- At room temperature, a gas is a gas
  - Example: Chlorine gas (Cl_2), oxygen gas (O_2)



- At room temperature, a vapor is in some other form
  - Example: Water Vapor (H_2O)

Pressure

solid phase

compressible liquid

supercritical fluid

critical pressure

P_{cr}

critical point

liquid phase

triple point

P_{tp}

gaseous phase

vapour

critical temperature

T_{cr}

T_{tp}

Temperature

Notice the gap here
water vapor is invisible

"Steam" is actually billions of
microscopic drops of water.

Application Areas of Fluid Mechanics



Natural flows and weather
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Boats
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Aircraft and spacecraft
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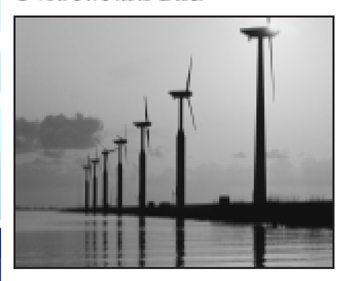
Power plants
© Vol. 57/Photo Disc.



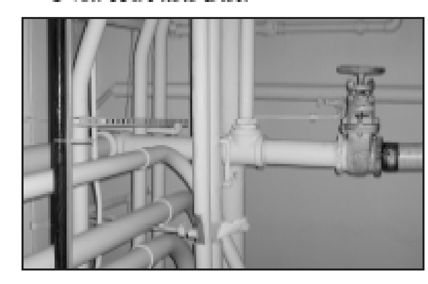
Human body
© Vol. 110/Photo Disc.



Cars
Photo by John M. Cimbala.



Wind turbines
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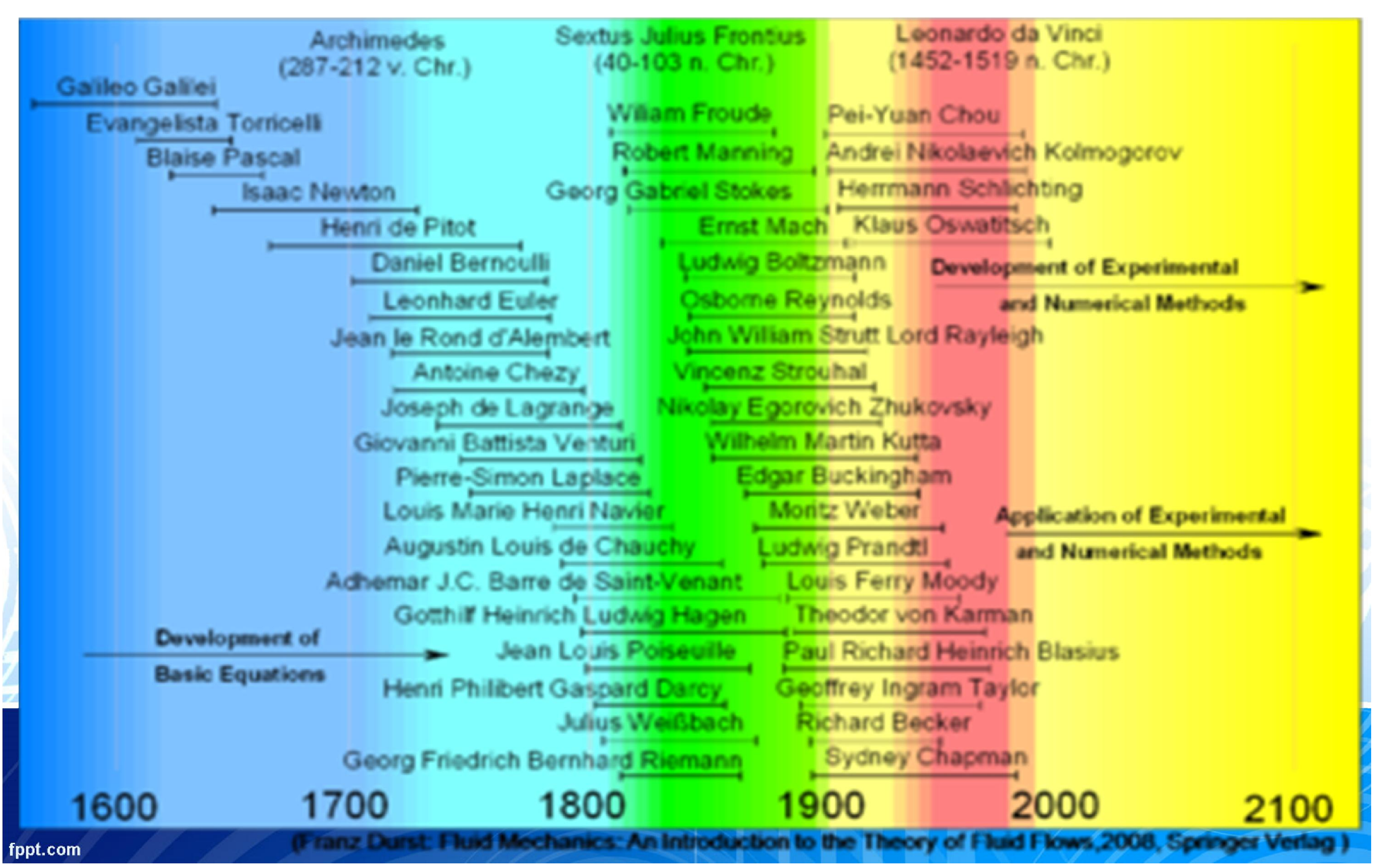


Piping and plumbing systems
Photo by John M. Cimbala.



Industrial applications
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History of Fluid Mechanics



Thank You

